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**Description****SPECIFICATION****BACKGROUND OF THE INVENTION**

The invention relates to laser bar code scanning apparatus and method. More specifically, the invention is concerned with a method and system for automated substantially attendant-free scanning of items or packages bearing bar code labels.

Bar code scanners have been in increasing use for scanning the UPC and other types of bar codes on packages or containers, particularly in retail stores with recent emphasis on grocery stores. Generally, in retail stores the scanners are set up at check-out stands, built into the horizontal check-out deck so that a laser beam is scanned up through a transparent window, defining a number of different scan lines in a scan geometry. Normally packages are placed by the customer on the counter or deck or on a conveyor. A check-out person then takes each package, visually locates or perceives the UPC or other bar code label on the package and moves the package through the scanner's scanning area holding the package in a particular orientation which will effect a good read by the scanner as the bar code traverses through the scanning area.

Some attempts have been made to minimize or eliminate the participation of checkout personnel. For example, in one system the customers themselves were directed to move the bar code bearing items through the scanning area in order to effect a listing and summation of the items and charges by computerized equipment associated with the scanner. Such a system has been marketed under the name Check Robot or Check Robot, Inc.

However, prior to the present invention, operator participation in the use of a point of sale scanner was always required, whether the operator was the customer or retail store personnel. It is an object of the present invention to eliminate or substantially eliminate any need for an operator to move items through a scanner, by automatically moving items through a scanning area and reading the bar codes on each item, regardless of orientation, so as to produce a listing and summation of items and charges almost totally automatically.

BE-A-0899019 discloses a point of sale bar code scanning apparatus. Items having bar codes thereon are carried by a conveyor belt to a bar code scanner. A laser beam scans the bar codes on the items and the information thus read is decoded. Thus, this document corresponds to the pre-characterising part of claim 1.

In BE-A-0899019, the items have to be positioned on the conveyor in a particular orientation, if the bar codes are to be read. The present invention

seeks to permit bar codes to be read when the bar code label may be located on any of a number of different surfaces of the item.

FR-A-2367320 discloses an arrangement for

5 reading bar code labels on different surfaces of an item. In this disclosure, mirrors are used to permit a television camera to view different surfaces of the item.

According to a first aspect of the present invention there is provided a point of sale bar code scanning apparatus for scanning bar code labels on items moving through a scan region comprising:

an item conveyor for receiving items placed thereon and for moving the items through an item path;

10 a bar code scanner for scanning with one or more laser beams a volume of space in which a product bar code label might be located, to read the label, the bar code scanner having a laser source within a scanner housing;

15 decoding means for receiving signals from the scanning of the bar code labels;

wherein:

the bar code scanner has scanning means for scanning in multiple directions to read the label which might be located on any of a number of different surfaces of the item, the scanning means comprising:

20 the laser source for producing the one or more laser beams;

25 a scanner housing with a first substantially vertical surface and a substantially horizontal surface forming the scan region therebetween;

30 a single scanning mechanism having a plurality of mirrors for reflecting the one or more laser beams in a plurality of directions to produce a plurality of scanning beams;

35 there are a plurality of deflecting mirrors for reflecting scanning beams through the vertical surface to produce a first scan pattern of scan lines; and

40 a plurality of deflecting mirrors for reflecting scanning beams through the horizontal surface to produce a second scan pattern of scan lines.

According to a second aspect of the present invention there is provided a method for automatically scanning bar code labels on selected items comprising the steps of:

45 placing items on an item conveyor;

moving the items placed on the item conveyor through an item path and through a scan region;

50 scanning with one or more laser beams a volume of space in which a product bar code label might be located to read the label;

assuring that only one item will be capable of being read and recorded at any one time;

55 receiving and decoding signals from the scanning of the bar code labels;

compiling data related to the items whose bar codes have been read and preparing a tabulation of

such items;

characterised in that:

the scanning with the one or more laser beams is in multiple directions through multiple surfaces of a scanner housing; and

the step of scanning comprises:

providing a rotating scanning mechanism in the scanner housing;

forming the scan region between a first surface positioned in a vertical plane which faces one side of the scan region and a second surface positioned in another plane which faces a second side of the scan region;

scanning in multiple directions by producing a first group of scanning beams and a second group of scanning beams by reflecting the laser light off the rotating scanning mechanism, reflecting the first group of scanning beams off a first set of directing mirrors and out the first vertical surface to produce a first scan pattern of scan lines in the scan region, and reflecting the second group of scanning beams off a second set of directing mirrors and out the second surface to produce a second scan pattern of scan lines in the scan region.

As a retail point of sale (POS) item scanner, the system of the invention permits a retail customer to place selected items one-by-one on a conveyor at a checkout location. The items are advanced by the conveyor and preferably serial conveyors are used so that items may be delayed at certain points to avoid two items being readable at any one time. Gate devices may be included in the system, sensing the advancing items and controlling the conveyors, delaying the admission of an additional item to the scanning area until a first item has been read or passed through the scan area. The scanner is enabled by the first item gate and disabled when the item is read. It may be enabled again when the item already read has left the scanner and the next item passes the first item gate. Alternatively, it may be enabled for reading only the new item, provided means are included for discriminating from the already-read item while it remains in the scan region.

In the scanning area, the item is transported by a moving conveyor through a scan volume comprised of a series of different scan patterns or lines approaching from different sides of the item. Preferably a single laser beam, or a pair of laser beams, are deflected by moving mirrors or a holographic beam deflector/scan generator to produce scan geometry which approaches the package or item from the top, angularly toward the sides so as to be capable of reading all sides, and also from the bottom of the package.

This scanning ability requires a rather large depth of field for the scanned beam(s). This is true because the package or item may be placed at a range of positions on the conveyor as it travels through the scan

volume; because of widely differing sizes of items; and because the bar code label could be located almost anywhere on any of the sides or ends of the package.

Such long depth of field is generally not possible from the laser beam in conventional product scanner apparatus, which typically relies on the correct bar code-bearing panel of a package being moved by a skilled operator closely adjacent to a surface-mounted scan window. Further, such depth of field generally is not available in the waist of a focussed beam, which in practical terms is limited in its depth of field to about plus or minus 1-1/2inch for reading UPC bar codes. However, a preferred embodiment of the present invention employs an extended depth of field beam system. In this system a pair of lasers, such as laser diodes, may be oriented at 90° to each other but, using a beam-combining reflector/transmitter, directed substantially into a common alignment. One beam has its range of acceptable focus farther distant than that of the other beam. The two beams preferably are pulsed in opposition to one another so that when one beam is "on" the other beam is "off", and the detecting apparatus therefore knows which beam is being used when a bar code is detected and read.

In this way, the depth of focus enhancement system "stacks" one beam in tandem with another in effect to double the depth of field of the composite beam, i.e. the depth or distance within which a bar code can be located for obtaining an accurate read. A six inch effective depth of field can be achieved with two laser beams.

An important aspect of the present invention is the handling of bottom reads. Since the bar code label may be on the bottom of a package, provision must be made for scanning the laser beam over the package's bottom as well as over all other surfaces. Different approaches are theoretically possible, such as using transparent belts as taught in GB-A-1 445 100, or sliding the product over a stationary glass window (which may be inclined) through which the beam is scanned. These approaches generally have problems. For example, a window over which items are repeatedly moved will scratch and the scratches in this case will be in the plane of focus of the scanning beam. Static and bad reads will occur.

In the preferred embodiment of the invention a conveyor is used for bottom reading which comprises a series of discrete belts or belt strips having parallel spaces between them through which the beam(s) is upwardly scanned. This provides a series of scan lines in one orientation, which will read the bottom-mounted UPC bar code if its bars are oriented anywhere from perpendicular to the scan lines preferably up to 45° to the scan lines. The discrete belts are narrow enough, and the adjacent space is narrow enough, that a bar code at 45° will be read by a scan line on one side or the other of each belt section when

the UPC bar code label fully straddles the belt.

The UPC bar code label comprises two halves read separately, each half having an oversquare amount sufficient to permit the label half to be read by one scan line or the other on either side at the belt strip with the label at a worst case angle of 45°. In other words, there are a series of parallel equally spaced scan lines oriented in the direction of travel of the items. The spacing between scan lines (with a belt between them) preferably is small enough that with the label at 45°, at least one of the parallel scan lines must cross all the bars in the half-label. This means, in the critical case where one scan line cuts diagonally across the base square of the half-label, an adjacent line must still cross all bars with the oversquare amount included. To meet this requirement, the maximum spacing between scan lines must be the bar code oversquare amount times one-half the square root of 2. For non-UPC bar codes that do not incorporate the "oversquare" feature, more complex scan line geometries are often required. This invention permits more complex scan geometries to read undersquare bar codes.

For bottom-located UPC bar code labels which are oriented at less than 45° with respect to the belt strips and to the scan lines between them, at least one additional scan line perpendicular to the belts is generated. Preferably a transverse scan line is included at the end of the series of belt strips, i.e. scanning a line generally parallel to and adjacent to a roller on which the belt strips or sections are mounted. There may be such a scan line at one or each of the forward and rearward ends of the conveyor which takes the packages through the scan area. That is, a beam may be scanned in a generally vertical plane both forward and aft of the scan area conveyor, the vertical planes being substantially perpendicular to the line of advancing movement of each of the belt strips. The scan lines generated by scanning in these vertical planes will read UPC bar code labels having bars perpendicular to the vertical planes up through labels having bars oriented at 45° to the vertical planes and to the scan lines generated therein. In fact, because of the oversquare feature of UPC bar codes, such a scan line will read labels at somewhat less than 45° to the scan line. However, the oversquare is intended to allow time to assure a read on a moving item.

Alternatively, the 45° criterion need not be rigidly adhered to. The parallel scan lines may be slightly farther apart than described above, provided they are sufficiently close that, considering the speed of conveyor movement and the repetition rate of the transverse scan line, substantially all orientations of bottom-located bar codes which are not read by the transverse scan line will be read by one of the parallel scan lines.

A preferred embodiment of the invention also includes provision for handling "no reads". These can

be handled in a number of different ways. First, if an item is not read on passing through the scan volume as determined by the item's moving through an exit gate without a successful read, the product preferably is returned to the customer via a return conveyor or a reversing of a conveyor, and an indicator instructs the customer to again place the item on the lead-in conveyor. It may instruct the customer to rotate the item.

If a "no read" again occurs, the package can then be recorded by a video camera for later reference of a cashier in identifying the product and its price. The video signal is stored and played back on a monitor at the cashier, so that the cashier can recognize the product and look up its price. Alternatively, the customer may be instructed by the system to carry the "no read" items separately to the cashier for manual checking.

In another system for handling "no reads", an auxiliary scanner is located adjacent to the automatic scanner. This scanner can comprise a fixed scanning "X", over which or past which the customer is automatically instructed to move the item, with the bar code properly oriented. Alternately this auxiliary scanner can comprise a light pen, with the customer instructed to move the light pen over the item's bar code.

The system of the invention preferably provides an itemized tally of a customer's selections, preferably with prices and with a total or subtotal. This may be printed on a receipt-like paper presented automatically to the customer. The customer may then carry the tally sheet or paper to the cashier, who will add onto the total any remaining "no read" items before collecting payment from the customer. The information may in addition or alternatively be conveyed electronically to the cashier.

Alternatively, the system can give the customer a list and description of all items selected, without totaling the list. Instead, a code can be imprinted on the tally sheet, such as a machine-readable bar code or other machine-readable code, containing the total price of all the items. This code can then be read by the cashier's machine (or the information can be sent electronically to the cashier), and any "no reads" can be added to the total at that point.

The system may convey the itemized list electronically to the cashier, with customer identification (or scanner lane number), without handling by the customer.

Items in the store without a fixed price, such as items sold by weight, can be handled as "no reads". However, the store will preferably have its own bar code encoding label printer at the location where the customer selects, weighs and bags the items, as many stores currently have.

The system of the invention therefore avoids the need for a cashier or checkout personnel at each

checkout station in a retail store, and enables the use of only minimal personnel as cashiers after items have already been checked and totaled automatically. The system is also applicable to non-retail situations, such as automatic monitoring and recording of inventory on input to a store, warehouse or distribution center. The system may be employed whenever items are conveyed from one point to another.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings, which by way of illustration, show preferred embodiments of the present invention and the principles thereof and what are now considered to be the best modes contemplated for applying these principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

#### DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view generally indicating the system of the invention.

Figure 2 is a schematic block diagram indicating components and steps involved in the process and system of the invention.

Figure 3A is a greatly simplified perspective view schematically indicating a beam distributor wheel in a general layout for generating scan geometry for reading all sides of an item passing through a scan volume.

Figure 3B is a longitudinal side elevation view schematically indicating right-side laser scan paths for scan geometry which may be used in accordance with the invention.

Figure 4 is a schematic top plan view showing directions of scanning for four vertical faces of an item moving on a conveyor in the system. Figure 4 also indicates an idealized cube within which a bar code can be read.

Figure 5 is a schematic plan view illustrating the principle of reading a moving bar code label with an "X" scan configuration.

Figure 6 is a view showing "X" scan lines on the face of a cube representing a scanned volume.

Figure 7 is a perspective view showing an "X" scan pattern imposed on the top surface of a moving item.

Figure 8 is a perspective view showing a scan area conveyor of an embodiment of the invention for accomplishing bottom reading, and comprising a plurality of discrete belts with spaces between the belts. Figure 8 also shows the location of a series of scan lines in parallel scanning planes between the belts and at one end of the scan volume conveyor.

Figure 9 is a schematic plan view illustrating prin-

ciples of the bottom reading system of the invention.

Figure 10A, 10B, 10C and 10D are views showing schematically basic components of a system of mirrors for providing the bottom scan. Figures 10A and 5 10B are plan views, Figure 10C is a side elevation view and Figure 10D is a transverse elevational section view.

Figure 11 is a perspective view similar to Figure 1, illustrating an aspect of the system of the invention for handling "no reads".

Figure 12 is a schematic view showing a depth of field enhancement system which may be used in accordance with the invention to read bar codes located within a relatively wide depth of field within the scan 15 volume.

#### DESCRIPTION OF PREFERRED EMBODIMENTS

In the drawings, Figure 1 shows an automatic package label scanner generally identified by the reference number 10. The system includes a shelf 12, adjacent to which a customer's basket 14 may be positioned for unloading of items; a lead-in conveyor belt 16; a scan area conveyor 18, for conveying items through a scan area or scan volume generally identified by the reference number 20 within which laser scanning lines are generated in a scan geometry designed to read all six sides of a typical box-shaped item; an exit conveyor 22; an exit storage area 24, such as for bagging of items read in the scan region or area 20; and a screen or display 26 for instructing the customer. Item gates 28 and 30, which may comprise photoelectric sensors, are positioned at the input and exit ends of the scan area 20, respectively, i.e. at the beginning and end of the scan area conveyor 18 as indicated. The item scanner is enabled by the first item gate 28 and preferably disabled when the item passing through is read. The scanner is enabled again when the item already read has left the scan area 20, passing the exit item gate 30, and the next item has passed the entry item gate 28. Once the first item is read, the scan belt may be speeded up to hasten that item's exit. In the event the first item has not left the scanning area or scanning region 20 before the second item crosses the item input gate 28, the input belt 16 may be stopped or automatically reversed to temporarily retard the progress of the second item.

Alternatively, the scanner may scan a new item entering the scan region after the first item is read but before it leaves the scan region. This may be by more sophisticated equipment for discriminating from the already-read item or following its progress and ignoring further reads which emanate from its position or blocking scan lines at its position.

The display 26, on approach by the customer, will instruct the customer to place items one at a time on the center line 32 of the input belt 16.

The system of the present invention addresses security by the fact that once the item has left the customer's hands, it is either read and conveyed through the scan region 20 to the bagging area 24, or it is not read and is returned to the customer in any of several possible means. The handling of "no reads" is discussed below.

Figure 2 is a block diagram and schematic layout showing the system of the invention and the manner in which it is used by a customer. Figure 2 also indicates interaction between components of the system.

Figure 2 shows the customer location A and generally indicates a conveyor belt or conveyor means or series of conveyor belts B between the customer location and a customer exit location C. The customer exit location becomes accessible after payment at a cashier D.

The scanner E is shown directed at the conveyor belt area and connected to a scan enable F which may be controlled by item gates G (28) and H (30) generally at either end of the scan region. A successful read is indicated at I, as a signal from the scanner E. In the event of a successful read, the scanning apparatus is shown sending a signal to the computer for item look-up.

No-read alternatives J include, as indicated, a TV camera which is enabled to store an image of a no-read item in the case of a no-read; a return of the item to the customer via the belt with reversal of the conveyor; and/or an instruction displayed for customer action. As indicated further in Figure 2, these actions may include instructions to use an auxiliary scanner, which may be fixed; the use of a light pen for reading the subject bar code manually by the customer; or an instruction for the customer to simply carry the no-read item to the cashier. Another means to handle no-reads is to include with the equipments described in Figures 1 and 11 a separate conveyor (not shown) to deliver unreadable items to a special location where a clerk scans them or keys them in.

Figure 3A is a simplified schematic drawing in perspective illustrating in general one arrangement which may be employed to generate scan geometry for reading all six surfaces of a typical item. Figure 3A shows the function of a distributor wheel 35 and the location of an idealized cube with respect to the distributor wheel.

The rotating distributor wheel 35 may have 12 different mirrors (as collectively indicated as 36), for effecting the generation of scan geometry including an "X" scan projected in five different directions (four directions for scanning the vertical surfaces of an item and one projected downwardly at the top), and for generating the bottom scan, all toward the idealized cube 37.

Figure 3A indicates a laser beam 38 projected up through a "bifocal" focusing and collection lens 39, to be distributed in a number of different beam sweeps

(which may be twelve) by the mirrors 36 on the distributor wheel 35. Figure 3A is simplified and only generally indicates a few of the mirrors which serve to direct the scanning beam into the appropriate scan line after reflection of the beam from the respective mirrors 36 of the distributor wheel.

Figure 4 indicates the scan directions preferably used in effecting scanning of the vertical faces of an item. As indicated in all of Figures 3A through 7, the projected X configuration, i.e. two scanning planes to produce scan lines substantially at right angles, will read any bar code label moved through the scan X assuming that the label passes through the beam waist wherein the beam is sufficiently focused to resolve the bar code lines. Figure 4 shows that the four scan directions for the vertical faces of the idealized cube or item 37 preferably are at 45° approaching from the front and 45° approaching from the rear.

Figure 3B, which can be considered to be a side elevational view, partly in section, shows generally the laser paths which may be used in accordance with the invention to achieve the "X" scans of Figure 4 and also the top scan, but excluding the bottom scan. The scan region conveyor 18 is shown in profile, with the direction of movement from left to right in Figure 3B as indicated by arrows. The beam distributor wheel 35 is seen below the conveyor 18, and the distributor wheel is rotating at an appropriate rate to achieve the proper repetition rate for each of the scan lines. The rate of rotation may be on the order of about twenty-five revolutions per second.

Figure 3B shows only the right scan laser paths, with the left scan (not shown) being somewhat similar, with certain differences. Beam directing mirrors are indicated for each of five scan lines generated with the right scan laser paths (excluding bottom scans). For example, for generating one scan line in the top scan "X", the laser beam 38 after leaving the appropriate distributor wheel mirror 36 is reflected by beam directing mirrors 40 and 41, ultimately to be directed toward the target, i.e. the center of a six inch idealized cube. The final path of this scan line is indicated by an arrow 42 in Figure 3B.

As also shown in Figure 3B, the beam 38 after leaving a different distributor wheel mirror 36 is reflected by beam deflecting mirrors 43 and 44 to produce one scan line of the scanning "X" which approaches from the front right of the idealized cube 37 (as shown in Figure 4). The other scanning line of this same front right scanning "X" is produced by another distributor mirror wheel mirror and by beam deflecting mirrors 45 and 46. The final scan paths of the two lines that make up this scanning "X" are indicated by arrows in Figure 3B at 47 and 48.

Similarly, the scanning "X" which approaches from the rear right of the idealized cube (see Figure 4) is produced by two further distributor wheel mirrors and by beam deflecting mirrors 49-50 and 51-52, re-

spectively, as indicated.

As mentioned above, a generally similar arrangement of mirrors, not shown, produces the scanning "X's" approaching the idealized cube from the left side, and those mirrors also producing the "left" scan line to complete the top scan "X".

Figure 5 illustrates the principle that any UPC label oriented at any angle in the plane of the paper will be scanned by a scan line which crosses all the black and white bars of the label. UPC labels which are not in the plane can also be read as long as a single scan crosses all the black and white bars.

Figure 6 illustrates the scanned beam X configuration which preferably is projected onto each of the four vertical faces of a cube representing the item passing through the scan volume. Figure 6 indicates with dotted lines at progressive positions the relative motion of the scan lines on the face of the cube 37, as the item is moved through the scan area. The item may be placed in any orientation, on the scan region belt 18, including with two faces parallel to the belt 18 or diagonally with respect to the belt 18 (see Figure 4). The projected scan lines forming the X scan will strike the vertical item faces obliquely if the item is parallel to the belt, but still will cross the faces in acceptable focus for reading the bar code, in accordance with the present invention.

Figure 7 illustrates an X configuration of scan lines 53 approaching the item or cube 37 from above, striking the top surface 54 of the item as the top scan. Again, as the item progresses through the scan volume or scan region, the bar code if located on the top surface 54, will be read by at least one of the X scan lines 53, assuming parameters of speed of product movement, beam focus, scan repetition rate, etc. are met.

Figure 8 illustrates schematically the conveyor means and system by which bottom reading is accomplished. In this preferred embodiment, the scan region conveyor 18 comprises a series of parallel discrete belts or belt strips 55, supported on rollers 56 and retained in properly spaced configuration. Figure 8 illustrates in dashed lines a series of bottom read scan lines 58 which project upwardly in substantially vertical planes between the adjacent belt strips 55. The spacing between adjacent scan lines 58 (including the width of the belt strip 55 therebetween) is narrow enough so that a bottom-located bar code label, if it would not be read by a transverse scan line 60 at one end of the scan area belt 18, will be read by at least one of the parallel scan lines 58.

This requirement is generally met if the spacing between adjacent scan lines 58 is such that at least one scan line 58 will always read the label when the label is at 45° to the parallel scan lines 58. However, because of the oversquare amount in a standard bar code label, it is possible at least in theory that the parallel scan lines can be spaced farther apart than what

would be required by the 45° requirement just described. The transverse scan line 60 should have the ability to read labels that are at 45° to the parallel scan lines 55 and in fact somewhat greater than 45° with respect to these lines (somewhat less than 45° with respect to the transverse scan line 60). This is again because of the oversquare amount in the bar code label, and this principle is indicated in Figure 9.

Figure 9 shows a bar code label 62 oriented at a theoretical worst-case position of 45° to the parallel scan lines 55 and to the transverse scan line 60. If a read is to be guaranteed at 45° then the critical maximum distance between adjacent scan lines 58 is illustrated as L. This is the distance which, using the oversquare portion 62a of the bar code 62, assures that one or the other of the two adjacent parallel scan lines 58 will cross all of the bars in the bar code, as illustrated. It can be seen that if the label 62 is shifted slightly up or down as seen in Figure 9, one of the adjacent scan lines 58 will be more squarely in position to read all the bars of the label.

The readings by these parallel scan lines 58 are not as item speed-dependent or repetition rate-dependent as with the transverse line 60, since the label 62 moves along with the belt strips 55 for an appreciable distance and time. If the motion of the belt strips 55 is reasonably precise, the label 62 will remain at essentially the same position with respect to each parallel scan line 58 throughout the travel of the bar code over the length of the scan line 58. The scan lines may each be, for example, about 1.2 inches in length.

Figure 9 illustrates that the transverse scan line 60, when the label is at 45°, has some latitude of distance M in reading the label 62, again because of the oversquare amount 62a as discussed above. However, the reading of the label by the scan line 60 within the envelope of distance and time M shown in Figure 9 is very much item-speed and repetition rate-dependent, more so than the situation with the parallel scan lines 58. If it is to be assured that either the parallel lines 58 or the transverse lines 60 will read the bottom label 62, and if the critical distance L between parallel lines is as shown, then the transverse line 60 must also obtain a good read, crossing all the bars substantially every time. This requires that the speed of item movement and the repetition rate of the transverse line 60 be such that the line 60 will be scan between the positions 60a and 60b illustrated in Figure 9, i.e. within the critical distance M, substantially every time. (At 45° as shown, both L and M are equal to the oversquare distance times one-half the square root of 2.)

Thus, as repetition rate of the transverse scan line 60 is made higher and the speed of item movement is made slower, the distance between parallel scan lines 58 can be made greater, so that the transverse scan line 60 is relied upon to read the label in a

greater range of angular orientation, and the parallel scan lines 58 will be relied upon in a lesser range of label orientations.

Therefore, the spacing between adjacent parallel scan lines 58 should be defined as narrow enough that, in orientations of the label wherein the transverse line 60 will not necessarily obtain a read, considering the repetition rate and the speed of item movement, one of the parallel lines 58 will necessarily obtain a read.

As outlined above, the 45° position of the label 62 preferably is used for purposes of design in accordance with the present invention. It is preferable that a read by the parallel scan lines 58 be assured at the 45° label position, with the distance between adjacent scan lines 58 being set at L as a maximum. L is equal to the oversquare amount divided by the square root of 2, or one half the square root of 2 times the oversquare amount. For standard (minimum size) UPC bar codes, this means that a 1/4 inch spacing between scan lines 58 will be under the maximum allowable distance L. In accordance with a preferred embodiment of the invention, the spacing between parallel scan lines is approximately 1/4 inch in width, which includes the belt strip width and one gap width.

Figures 10A, 10B, 10C and 10D illustrate generally the manner in which the bottom scan lines may be generated, including both the transverse or cross sectional scan lines 60 and the parallel scan lines 58. As illustrated, each of the parallel or inline scan lines 58 spans a portion of the overall length of travel of the scan region conveyor. This is primarily due to optics involved in this preferred embodiment of the invention.

The cross sectional or transverse scan line 60 may be at the downstream end of the scan region conveyor, as indicated.

Figure 10B, another schematic plan view rotated at 90° to Figure 10A, shows generally a series of mirrors which may be used to reflect a scanned beam from the distributor wheel 35 to produce the transverse scan line 60 and the series of parallel or inline scan lines 58. Figure 10B should be viewed in conjunction with Figures 10C and 10D.

In accordance with this preferred embodiment, all of the bottom scan lines (transverse and inline) are generated by two of the mirrors 36 on the distributor wheel 35. One distributor wheel mirror 36 preferably generates one half the transverse or cross sectional scan line 60 and one side, either left or right, of inline scans 58. Thus, if there are twelve parallel scan lines 58 as shown in Figures 3A and 3B, the beam sweeping from one of the distributor wheel mirrors 36 will generate either the left six or the right six.

Figure 10C illustrates that in accordance with the invention, the beam sweeping from one of the distributor wheel mirrors 36 may first form a left half of the transverse or cross sectional scan line 60 by reflection off beam deflector mirrors 65 and 66 shown in Figure 10C, then all six of the right side inline or parallel scan lines 58 (see Figure 10D), by reflection off a beam deflection mirror 68, then off a mirror pair 70, 72 (Figure 10B). Following the mirror pair 70, 72 are a series of successive final-reflection inline mirror segments 74 (bearing notations A through F in Figure 10B).

The mirror pair 70, 72 and the final mirrors 74A through F are also seen in the transverse cross sectional elevation view of Figure 10D. Figure 10D shows an example of the beam 38 leaving the right inline beam deflector mirror 68 and then reflecting off the mirror pair 70, 72, finally to be reflected off the final mirror segment 74E and up through a gap 64 in the scan area conveyor 18.

The sequence described above is repeated for the scan lines opposite those just described. As can be seen from Figure 10B, the other half of the transverse scan line 60 is generated by a different distributor wheel mirror 36 sweeping the beam off a first right cross sectional mirror 76 and then a second right cross sectional mirror 78, to produce the right half of the transverse scan line 60. The same beam will then form the six right inline or parallel scan lines, with the rest of its arc of sweep. This is by reflection off a left inline beam deflector mirror 80, a left inline mirror pair 82, 83 and a series of left inline mirror segments 84A through 84F, as illustrated in Figures 10D and 10B.

It should be understood that the arrangements of mirrors shown schematically in Figures 3A, 3B and 10A through 10D are merely exemplary, and other arrangements can be used. For example, the needed scan geometry could be generated with two mirror wheels on one rotational shaft, each mirror wheel receiving a portion of the laser beam after splitting by a beam splitter. This can be an effective system for directing the beam into the scan volume from different angles. Selective use of independent laser-scanner-detector subsystems located to produce segments of the pattern already described is another example.

In an automatic scanning system, there will inevitably be a number of "no reads". This can be for a variety of reasons, such as product size, irregularity of shape, location of the bar code label, damaged bar code, and other factors.

Figure 11 illustrates a portion of the system of the invention, in a "no read" mode. Preferably the first or lead-in conveyor belt 16 is very short, for example about eight inches long. This discourages or makes it difficult for the customer to put more than one item on this input belt at one time.

When an item in the scan region 20 reaches the second item gate 30 and has not been read, both the scan region belt 18 and the input belt 16 can then be automatically reversed to return the item to the customer at the shelf 12. The display 26 then preferably

displays a message such as "PLEASE ROTATE ITEM AND PRESS 'GO'". This signifies that the customer should press the "GO" button 90 indicated in Figure 11. In addition, an audible message may be included, instructing the customer in the same way. It will be apparent to the customer what item is being referred to, since only one item was returned from the scan region 20 and since the input belt 18 is very short, most likely holding only one item at any one time.

If a "no read" again occurs, a video camera 92 (Figure 1) may be used to automatically record the image of the "no read" item, for reference by a cashier on a monitor at the time of payment.

As an alternative, or in addition to the use of the video camera 92, the system can include a light pen 94, with the customer appropriately instructed to use the light pen to read the item after two occurrences of "no read". For example, on the second "no read" pass, the belts can reverse and return the item to the customer, with the screen 26 displaying the message "PLEASE MOVE LIGHT PEN OVER BAR CODE LABEL OF ITEM". Then, if a successful read occurs with the light pen, the screen 26 can instruct the customer to by-pass the scan region 20 with that item and move it directly to the output conveyor 22.

As an alternative to the light pen, the system can include a fixed scan window 96, over which the customer is instructed to move the item with the bar code appropriately oriented.

A large depth of field for resolving bar codes with the scanned beam is essential in the system of the invention, primarily because of widely varying sizes of items and varying placement of items on the conveyor by the customer. The beam waist capable of resolving a standard (minimum size) bar code in a typically focused laser beam is limited to about three inches, i.e. plus or minus 1.5 inches from the point of best focus. This is generally not sufficient for the system of the present invention, which must achieve a very high successful first read rate.

An enlarged depth of field subsystem doubles the available depth of focus to about six inches, so that the ability to read bar codes at varying distances is greatly enhanced.

Figure 12 illustrates the principle of the depth of field enhancement subsystem used in a preferred embodiment of the present invention. The system employs two polarized laser beams 100 and 102 directed from positions 90° from each other toward a beam-splitter/combiner element such as a beam-splitter cube 104. The beam-splitter cube 104 allows the superposition of two polarized laser beams without loss of power, by transmitting substantially 100% of beam power from the polarized beam 100 and reflecting substantially 100% of beam power from the polarized beam 102, whose polarization is at right angles to that of the beam 100. A lower cost, conventional beam-splitter could be used as an alternative, since power

loss may not be an issue.

Preferably, the sources of the polarized beams 100 and 102 are laser diodes 106 and 108. A microprocessor 110 of the scanning system, also associated with the decode system, can switch instantaneously from one diode to the other depending on the level and modulation of the return signal received by the scanner. The two diodes 100 and 102 are never energized simultaneously. Thus, at a time when the first diode 100 is energized, and the decode system indicates that the level and modulation of the return signal do not indicate a focused beam scanning over a bar code, the microprocessor 110 can instantaneously switch to the other diode 102. The return signal from each beam can be measured alternatively then the signal with largest modulation can be used for decoding, representing the beam in best focus at the bar code. Other means for increasing the useful depth-of-field for scanning bar code labels, are possible. For example, mechanical means can be used for moving different lenses into the path of the laser beam to focus it at different locations. Alternatively, a pair of lenses in the beam with means to adjust separation between lenses axially can be used.

In operation of the system of the invention, as used as a retail point-of-sale scanner, a customer moves the shopping cart 14 adjacent to the shelf 12 at one of a series of check-out locations as indicated in Figure 1. The customer is instructed by the display 26 or by a separate sign to press a start button 90 or the customer otherwise initiates the startup of the conveyor belts 16, 18 and 22. For example, the initiation can be by a photodetector (not shown) detecting the presence of the first item placed on the shelf 12. (The no-read "GO" button 90 can also serve as a start button.)

With this initiation, the scanner system may assign a customer number to the customer, assuming the previous customer has finished. The customer unloads items onto the shelf 12, and is instructed to place items one at a time on the center line 32 of the lead-in or input belt 16 (as indicated in Figure 1). The first item is moved by the belt 16 across the first item gate 28 and into the scan region 20, and is conveyed through the scan region by the scan region conveyor 18. The scanner is then activated to attempt a reading from all sides of the items, including four approaches to vertical faces of the item as illustrated in Figure 4, including a top scan (see Figures 3A and 3B), and via the bottom scan up through the conveyor 18 as explained above with reference to Figures 8 through 10D. The scan area conveyor 18 preferably has a speed greater than the speed of the input conveyor 16, to insure that there is some space between the items. This allows the item gates 28 and 30 to keep track of each item, preferably along with a product number.

The scanner itself, via the system of mirrors

schematically indicated in Figures described above, is designed to scan the six faces of an idealized cube with two scan lines for each face substantially at 90° to each other in an "X", as discussed above. The X configuration achieves the omnidirectional scanning without redundant scan lines. The laser beam and retrodirective optics are directed vertically up from below the idealized cube, by a beam distribution system such as described above.

Each of the scan lines is sent out from a different final reflection mirror.

The distribution wheel 35 shown in Figure 3 may run at about 1500 RPM, so that each scan line has a repetition rate of 1500 per minute or 25 per second. However, this may vary with belt speed and other factors discussed above.

Each beam is finally reflected by beam deflection mirrors onto one of the six faces of the idealized cube. The distance from the collection lens of the reading optics to the face of each cube is held constant (and may be about 36.5 inches) to allow the same optics to be used for each scan line.

As outlined above, if an item is read successfully on the first pass through the scan region, this is noted in the microprocessor and the item crosses the second item gate, allowing a succeeding item to be delivered onto the scan region conveyor 18. However, if a succeeding item is placed too far up the input conveyor 16 by a customer and reaches the item gate 28 before the first item has crossed the second item gate 30, the input conveyor 16 may be stopped to prevent the second item from progressing into the scan region until the first item has exited. The first item gate 28 preferably is positioned a short distance back from the beginning of the scan region conveyor 18.

There will be some "no reads", and "no reads" may be addressed as outlined above. First, the item is returned to the customer via reversal of the conveyors 18 and 16, and the customer is instructed to rotate the item to a different position and again place it on the center line of the belt 16, as discussed with respect to Figure 11. If again a "no read" occurs, the customer is preferably instructed to use the light pen 94 (Figure 11) or the auxiliary window 96 to effect a proper reading, if possible. If a good read is obtained with the light pen, the customer is instructed to bypass the scan region and place the item at the bagging station. If again a good read is not obtained, even using the light pen, the video camera 92 can automatically record an image of the "no read" item, which will be displayed on a monitor at the cashier station. This enables the cashier to identify the product and its price and manually add this to the total. The system may also give the cashier a total number of items that have been read, in case the customer's bag needs to be checked for security reasons.

Once all of the customer's items have been moved through the scanner system 10, including "no

reads", they may be bagged by the customer or by a bagging assistant. From here, they are taken to the cashier along with a dispensed list or tally 112 (not shown) of the items which may bear a machine-readable code as discussed above, and the customer is charged the appropriate amount by the cashier. Alternatively, or in addition, the list may be conveyed electronically to the cashier along with a customer number. Some form of list or display preferably is shown to the customer before the customer approaches the cashier.

While we have illustrated and described the preferred embodiments of our invention, it is to be understood that these are capable of variation and modification, and we therefore do not wish to be limited to the precise details set forth, but desire to avail ourselves of such changes and alterations as fall within the purview of the following claims.

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## Claims

1. A point of sale bar code scanning apparatus for scanning bar code labels on items moving through a scan region (20) comprising:  
an item conveyor (16) for receiving items placed thereon and for moving the items through an item path;  
a bar code scanner (10) for scanning with one or more laser beams a volume of space in which a product bar code label might be located, to read the label, the bar code scanner (10) having a laser source within a scanner housing;  
decoding means (110) for receiving signals from the scanning of the bar code labels;  
characterised in that  
the bar code scanner (10) has scanning means for scanning in multiple directions to read the label which might be located on any of a number of different surfaces of the item, the scanning means comprising:  
the laser source for producing the one or more laser beams;  
a scanner housing with a first substantially vertical surface and a substantially horizontal surface forming the scan region (20) therebetween;  
a single scanning mechanism (35) having a plurality of mirrors (36) for reflecting the one or more laser beams in a plurality of directions to produce a plurality of scanning beams (38);  
there are a plurality of deflecting mirrors (40-41,43-44,45-46) for reflecting scanning beams through the vertical surface to produce a first scan pattern of scan lines (42,47,48); and  
a plurality of deflecting mirrors (65-84) for reflecting scanning beams through the horizontal surface to produce a second scan pattern of scan

- lines (58,60).
2. A scanning apparatus according to claim 1, including bottom reading means and a moving scan region conveyor (18) which comprises a plurality of parallel belt strips (55), with means for scanning a beam (58, 60) up through spaces between the belt strips and up through transverse gaps at either end of the scan region conveyor to read a bar code located on the bottom of an item.
3. A scanning apparatus according to claim 1 or claim 2, wherein the means for scanning in multiple directions includes means for scanning the laser beam with enhanced depth of field capable of resolving a UPC or other bar code label.
4. A scanning apparatus according to any one of the preceding claims, including item return means for returning "no read" items which the scanner is unable to read.
5. A scanning apparatus according to any one of the preceding claims, wherein the item conveyor comprises a plurality of separate conveyors serially positioned, including a short first conveyor belt (16), sufficiently short to discourage a customer from placing more than one item on the first conveyor, and a scan region conveyor belt (18) downstream of the first conveyor belt for conveying items through the scan region (20).
6. A scanning apparatus according to claim 5, wherein the scan region conveyor belt (18) has a speed which is higher than the speed of the first conveyor belt (16), so that an item in the scan region (20) moves faster than an item approaching the scan region, thereby reducing the likelihood of an item reaching the scan region before a preceding item has exited the scan region.
7. A scanning apparatus according to claim 5, further including means for increasing the speed of the scan region conveyor belt (18) once an item has been read.
8. A scanning apparatus according to any one of the preceding claims, further including a depth of field enhancement system for the scanning beams, comprising:
- separate first and second laser sources (106,108), each producing a respective laser beam (100,102);
  - beam combining means (104) for superimposing the two laser beams substantially on a single beam path, the beams being oriented in the same direction;
  - focusing means associated with each of
- the laser beams, including first beam focusing means for focusing the first laser beam to converge to a first focal plane at a first position in space and second beam focusing means for focusing the second laser beam to converge to a second focal plane at a second position in space, spaced from the first focal plane;
- each laser beam having a beam waist sufficiently focused to resolve a typical bar code, and the two focal planes of the two laser beams being spaced at a distance such that most of the beam waist of the second laser beam is non-co-extensive from the beam waist of the first laser beam so as to generally add the two beam waists to produce a longer effective bar code resolving depth of field than the beam waist of either laser beam.
9. A scanning apparatus according to claim 8, wherein the first and second laser sources comprise laser diodes (106,108).
10. A scanning apparatus according to any one of claims 1 to 7, wherein the laser source comprises a first laser diode (106) and a second laser diode (108), the first laser diode producing a first laser beam (100) and the second laser diode producing a second laser beam (102).
11. A scanning apparatus according to any one of claims 1 to 7, wherein the laser source comprises a first laser source (106) producing a first laser beam (100) and a separate second laser source (108) producing a second laser beam (102).
12. A scanning apparatus according to any one of claims 8 to 11, wherein only one of the laser beams is emitted at any one time.
13. A scanning apparatus according to any one of claims 8 to 12, wherein the decoding means (110) measures, when a signal has been received, the return signal from each beam alternatively, and using the signal with larger modulation, representing the laser beam in best focus for decoding.
14. A scanning apparatus according to any one of claims 8, 9 and claims 12, 13 when dependent on claim 8, wherein the beam combining means comprise a beam splitter (104), with the first and second laser sources outputting polarized beams directed at the beam splitter from orientations substantially at right angles with respect to each other, with the laser beams emerging from the beam splitter along a common beam path.
15. A scanning apparatus according to any one of claims 8 to 14, wherein the beam waists are sub-

- stantially non-coextensive so as to be fully added together with tandem to produce a bar code resolving depth of field essentially equal to the total depth of the two beam waists.
16. A scanning apparatus according to any one of claims 8 to 15, including laser source switching means for switching the first and second laser sources on and off in opposition to each other with a fixed periodicity.
17. A scanning apparatus according to any one of claims 8 to 16, including automatic means for initially switching the first and second laser sources on alternatively to determine the character of reflection of reflected light received and for selecting the laser source having the best return signal indicating the best focus and for continuing the scan line with that laser source.
18. A scanning apparatus according to any one of the preceding claims, wherein the plurality of deflecting mirrors comprises a plurality of mirror pairs (40-41, 45-46, 65-66) wherein a respective scan line is produced by directing a respective scanning beam (38) off a first deflecting mirror (40, 43, 45, 65) of a mirror pair and subsequently off a second deflecting mirror (41, 44, 46, 66).
19. A scanning apparatus according to any one of the preceding claims, wherein the scanning mechanism comprises a rotating wheel.
20. A scanning apparatus according to claim 19, wherein the rotating wheel comprises a distributor wheel having a plurality of mirror holders mounted thereon, each mirror on the scanning mechanism being mounted in a respective mirror holder.
21. A scanning apparatus according to any one of the preceding claims, further comprising a second vertical surface positioned parallel to and facing the first vertical surface, the horizontal surface being positioned between and below the first and second vertical surfaces thereby forming the scan region (20) between the first and second vertical surfaces and above the horizontal surface; and  
a plurality of deflecting mirrors for reflecting scanning beams through the second vertical surface to produce a third scan pattern of scan lines.
22. A scanning apparatus according to any one of claim 1 to 7, wherein the laser source comprises a single laser diode (106) for producing laser light consisting of a single laser beam (38), the single
- 5      23. A scanning apparatus according to any one of the preceding claims, wherein the one or more laser beams is passed through a beam splitter (104) between the laser source and the scanning mechanism.
- 10     24. A scanning apparatus according to any one of the preceding claims, wherein the scanning mechanism comprises two mirror wheels on one rotational shaft, each mirror wheel receiving a laser beam.
- 16     25. A method for automatically scanning bar code labels on selected items comprising the steps of:  
placing items on an item conveyor (16);  
moving the items placed on the item conveyor (16) through an item path and through a scan region (20);  
scanning with one or more laser beams a volume of space in which a product bar code label might be located to read the label;  
assuring that only one item will be capable of being read and recorded at any one time;  
receiving and decoding signals from the scanning of the bar code labels;  
compiling data related to the items whose bar codes have been read and preparing a tabulation of such items;  
characterised in that:  
the scanning with the one or more laser beams is in multiple directions through multiple surfaces of a scanner housing (10); and  
the step of scanning comprises:  
providing a rotating scanning mechanism (35) in the scanner housing (10);  
forming the scan region (20) between a first surface positioned in a vertical plane which faces one side of the scan region and a second surface positioned in another plane which faces a second side of the scan region;  
scanning in multiple directions by producing a first group of scanning beams and a second group of scanning beams by reflecting the laser light off the rotating scanning mechanism, reflecting the first group of scanning beams off a first set of directing mirrors and out the first vertical surface to produce a first scan pattern of scan lines in the scan region, and reflecting the second group of scanning beams off a second set of directing mirrors and out the second surface to produce a second scan pattern of scan lines in the scan region.
- 40     26. A method according to claim 25, wherein the second surface is positioned in a horizontal plane be-

neath the scan region (20).

27. A method according to claim 25, wherein the second surface is positioned in a vertical plane parallel to and facing the first surface on a side of the scan region opposite to the first surface.

#### Patentansprüche

1. Strichcode-Abtastvorrichtung für ein Verkaufskanal zum Abtasten von Strichcode-Etiketten auf Artikeln, die sich durch einen Abtastbereich (20) bewegen, umfassend:  
 eine Artikel-Fördereinrichtung (16) zur Aufnahme der darauf gelegten Artikel und zu deren Transport durch einen Artikelweg;  
 einen Strichcode-Scanner (10), um mit einem oder mehreren Laserstrahlen ein Raumvolumen abzutasten, in dem sich das Strichcode-Etikett des Produkts befinden kann, um das Etikett zu lesen, wobei der Strichcode-Scanner (10) eine Laserquelle innerhalb eines Scanner-Gehäuses aufweist;  
 ein Decodiermittel (110) zum Empfang von Signalen aus dem Abtasten der Strichcode-Etiketten;  
 dadurch gekennzeichnet, daß:  
 der Strichcode-Scanner (10) ein Abtastmittel zum Abtasten in mehreren Richtungen aufweist, um das Etikett zu lesen, das auf einer beliebigen einer Anzahl unterschiedlicher Oberflächen des Artikels angeordnet ist, wobei das Abtastmittel folgendes umfaßt:  
 die Laserquelle zur Erzeugung des einen oder mehrerer Laserstrahlen;  
 ein Scanner-Gehäuse mit einer ersten, im wesentlichen vertikalen Oberfläche und einer im wesentlichen horizontalen Oberfläche, die zwischen den Abtastbereich (20) bilden;  
 einen einzelnen Abtastmechanismus (35) mit einer Vielzahl an Spiegeln (36) zur Reflexion des einen oder mehrerer Laserstrahlen in einer Vielzahl an Richtungen, um eine Vielzahl an Abtaststrahlen (38) zu erzeugen;  
 eine Vielzahl an Ablenkspiegeln (40-41, 43-44, 45-46) zur Reflexion der Abtaststrahlen durch die vertikale Oberfläche hindurch, zur Erzeugung eines ersten Abtastmusters von Abtastlinien (42, 47, 48); und  
 eine Vielzahl an Ablenkspiegeln (65-84) zur Reflexion von Abtaststrahlen durch die horizontale Oberfläche hindurch, zur Erzeugung eines zweiten Abtastmusters von Abtastlinien (58, 60).
2. Abtastvorrichtung nach Anspruch 1, umfassend ein Boden-Lesemittel und ein sich bewegendes Abtastbereich-Förderband (18), das eine Vielzahl paralleler Bandstreifen (55) enthält, umfassend Mittel zum Scannen eines Strahls (58, 60) nach oben durch Zwischenräume zwischen den Bandstreifen hindurch und nach oben durch Querspalte an jedem der beiden Enden des Abtastbereich-Förderbands hindurch, um einen Strichcode zu lesen, der sich an der Unterseite eines Artikels befindet.
3. Abtastvorrichtung nach Anspruch 1 oder 2, worin das Mittel zum Scannen in mehreren Richtungen ein Mittel zum Scannen des Laserstrahls mit verbesserter Schärfentiefe aufweist, die einen UPC oder ein anderes Strichcode-Etikett auflösen kann.
4. Abtastvorrichtung nach einem der vorhergehenden Ansprüche, umfassend ein Artikel-Rückfährmittel zum Zurückführen "nicht-gelesener" Artikel, die der Scanner nicht lesen kann.
5. Abtastvorrichtung nach einem der vorhergehenden Ansprüche, worin der Artikelförderer eine Vielzahl getrennter, in einer Reihe positionierter Fördereinrichtungen umfaßt, einschließlich eines kurzen ersten Förderbands (16), das ausreichend kurz ist, um einen Kunden davon abzuhalten, mehr als einen Artikel auf das erste Förderband zu legen, und eines Abtastbereich-Förderbands (18) stromabwärts vom ersten Förderband zum Transport von Artikeln durch den Abtastbereich (20).
6. Abtastvorrichtung nach Anspruch 5, worin das Abtastbereich-Förderband (18) eine Geschwindigkeit aufweist, die höher als die Geschwindigkeit des ersten Förderbands (16) ist, sodaß sich ein Artikel im Abtastbereich (20) schneller bewegt als ein Artikel, der sich dem Abtastbereich nähert, wodurch die Wahrscheinlichkeit verringert wird, daß ein Artikel den Abtastbereich erreicht, bevor ein vorangegangener Artikel den Abtastbereich verlassen hat.
7. Abtastvorrichtung nach Anspruch 5, weiters umfassend ein Mittel zur Erhöhung der Geschwindigkeit des Abtastbereich-Förderbands (18), sobald ein Artikel gelesen wurde.
8. Abtastvorrichtung nach einem der vorhergehenden Ansprüche, die weiters ein Schärfentiefe-Verbesserungssystem für die abtastenden Strahlen enthält, umfassend:  
 getrennte erste und zweite Laserquellen (106, 108), die jeweils einen Laserstrahl (100, 102) erzeugen;  
 Strahlenkombinierungs-Mittel (104) zum Überlagern der beiden Laserstrahlen auf einem im we-

- sentlichen einzelnen Strahlenweg, wobei die Strahlen in der gleichen Richtung ausgerichtet sind;
- Bündelungsmittel, die mit jedem der Laserstrahlen in Verbindung stehen, umfassend ein erstes Strahlenbündelungs-Mittel zum Fokussieren des ersten Laserstrahls, um zu einer ersten fokalen Ebene an einer ersten Position im Raum zu konvergieren, und ein zweites Strahlenbündelungs-Mittel zum Fokussieren des zweiten Laserstrahls, um zu einer zweiten fokalen Ebene an einer zweiten Position im Raum zu konvergieren, die von der ersten fokalen Ebene beabstandet ist; wobei jeder Laserstrahl einen Strahlen-Engbereich aufweist, der ausreichend gebündelt ist, um einen typischen Strichcode aufzulösen und wobei die zwei fokalen Ebenen der beiden Laserstrahlen in einer solchen Entfernung beabstandet sind, daß sich ein Großteil des Strahlen-Engbereichs des zweiten Laserstrahls in seiner Erstreckung vom StrahlenEngbereich des ersten Laserstrahls unterscheidet, um allgemein die zwei StrahlenEngbereiche zu addieren, um einen längere, wirkungsvolle, strichcodeauflösende Schärfentiefe als der Strahlen-Engbereich jedes einzelnen der beiden Laserstrahlen zu erzeugen.
9. Abtastvorrichtung nach Anspruch 8, worin die erste und zweite Laserquelle Laserdioden (106, 108) umfassen.
  10. Abtastvorrichtung nach einem der Ansprüche 1 bis 7, worin die Laserquelle eine erste Laserdiode (106) und eine zweite Laserdiode (108) umfaßt, wobei die erste Laserdiode einen ersten Laserstrahl (100) und die zweite Laserdiode einen zweiten Laserstrahl (102) erzeugt.
  11. Abtastvorrichtung nach einem der Ansprüche 1 bis 7, worin die Laserquelle eine erste Laserquelle (106), die einen ersten Laserstrahl (100) erzeugt, und eine getrennte zweite Laserquelle (108), die einen zweiten Laserstrahl (102) erzeugt, umfaßt.
  12. Abtastvorrichtung nach einem der Ansprüche 8 bis 11, worin jeweils nur einer der Laserstrahlen ausgestrahlt wird.
  13. Abtastvorrichtung nach einem der Ansprüche 8 bis 12, worin das Decodiermittel (110) bei Empfang eines Signals das Rücksignal von jedem Strahl alternierend mißt und das Signal mit größerer Modulation, das den Laserstrahl in bestmöglichster Bündelung darstellt, für das Decodieren verwendet.
  14. Abtastvorrichtung nach einem der Ansprüche 8 und 9 sowie Ansprüche 12 und 13, wenn diese von Anspruch 8 abhängen, worin die Strahlenkombinierungs-Mittel einen Strahlenspalter (104) aufweisen, wobei die erste und die zweite Laserquelle polarisierte Strahlen aussenden, die am Strahlenspalter aus im wesentlichen rechtwinkeligen Ausrichtungen zueinander gerichtet sind, wobei die Laserstrahlen entlang eines gemeinsamen Strahlenwegs aus dem Strahlenspalter austreten.
  15. Abtastvorrichtung nach einem der Ansprüche 8 bis 14, worin sich die Strahlen Engbereiche im wesentlichen nicht gemeinsam miteinander erstrecken, um vollständig miteinander addiert zu werden, um eine strichcodeauflösende Schärfentiefe zu erzeugen, die im wesentlichen der gesamten Schärfentiefe der zwei Strahlen-Engbereiche entspricht.
  16. Abtastvorrichtung nach einem der Ansprüche 8 bis 15, umfassend ein Laserquellen-Umschaltmittel zum jeweils gegensätzlichen Ein- und Ausschalten der ersten und zweiten Laserquelle mit fixer Periodizität.
  17. Abtastvorrichtung nach einem der Ansprüche 8 bis 16, umfassend ein automatisches Mittel zum anfänglichen alternierenden Einschalten der ersten und der zweiten Laserquelle, um die Eigenschaft der Reflexion des empfangenen reflektierten Lichts zu bestimmen, und zum Auswählen der Laserquelle mit dem besten Rücksignal, das die beste Fokussierung anzeigt, sowie zur Fortsetzung der Abtastlinie mit dieser Laserquelle.
  18. Abtastvorrichtung nach einem der vorhergehenden Ansprüche, worin die Vielzahl an Ablenkspiegeln eine Vielzahl an Spiegelpaaren (40-41, 45-46, 65-66) umfaßt, worin eine jeweilige Abtastlinie durch Führen eines jeweiligen Abtaststrahls (38) weg von einem ersten Ablenkspiegel (40, 43, 45, 65) eines Spiegelpaares und anschließend weg von einem zweiten Ablenkspiegel (41, 44, 46, 66) gebildet wird.
  19. Abtastvorrichtung nach einem der vorhergehenden Ansprüche, worin der Abtastmechanismus eine sich drehende Scheibe umfaßt.
  20. Abtastvorrichtung nach Anspruch 19, worin die sich drehende Scheibe eine Verteilerschelbe mit einer Vielzahl an darauf montierten Spiegelhaltern umfaßt, wobei jeder Spiegel auf dem Abtastmechanismus in jeweils einem Spiegelhalter befestigt ist.
  21. Abtastvorrichtung nach einem der vorhergehenden

- den Ansprüche, weiters umfassend eine zweite vertikale Oberfläche, die parallel zur ersten vertikalen Oberfläche positioniert und dieser zugewandt ist, wobei die horizontale Oberfläche zwischen und unterhalb der ersten und zweiten vertikalen Oberfläche positioniert ist, wodurch sich ein Abtastbereich (20) zwischen der ersten und zweiten vertikalen Oberfläche und oberhalb der horizontalen Oberfläche bildet; und eine Vielzahl an Ablenkspiegeln zum Reflektieren von Abtaststrahlen durch die zweite vertikale Oberfläche hindurch zur Bildung eines dritten Abtastmusters an Abtastlinien.
22. Abtastvorrichtung nach einem der Ansprüche 1 bis 7, worin die Laserquelle eine einzelne Laserdiode (106) zur Erzeugung von Laserlicht, bestehend aus einem einzelnen Laserstrahl (38), umfaßt, wobei der einzelne Laserstrahl auf den Abtastmechanismus zur Bildung der Abtaststrahlen gerichtet ist.
23. Abtastvorrichtung nach einem der vorhergehenden Ansprüche, worin der eine oder mehrere Laserstrahl(en) durch einen Strahlenspalter (104) zwischen der Laserquelle und dem Abtastmechanismus hindurchgeführt wird (werden).
24. Abtastvorrichtung nach einem der vorhergehenden Ansprüche, worin der Abtastmechanismus zwei Spiegelscheiben auf einer Drehwelle umfaßt, wobei auf jede Spiegelscheibe ein Laserstrahl trifft.
25. Verfahren zum automatischen Abtasten von Strichcode-Etiketten auf ausgewählten Artikeln, umfassend die folgenden Schritte:
- das Legen von Artikeln auf einen Artikel-Förderer (16);
- das Bewegen der auf den Artikel-Förderer (16) gelegten Artikel durch einen Artikelweg und einen Abtastbereich (20) hindurch;
- das Abtasten eines Raumvolumens, in dem ein Strichcode-Etikett eines Produkts zum Lesen des Etiketts angeordnet sein kann, mit einem oder mehreren Laserstrahlen;
- das Sicherstellen, daß zu einem Zeitpunkt jeweils nur ein Artikel gelesen und aufgezeichnet werden kann;
- das Empfangen und Decodieren von Signalen aus dem Abtasten der Strichcode-Etiketten;
- das Zusammenstellen von Daten in bezug auf jene Artikel, deren Strichcodes gelesen wurden, und das Erstellen einer Tabelle solcher Artikel; dadurch gekennzeichnet, daß:
- das Abtasten mit einem oder mehreren Laserstrahlen in mehreren Richtungen durch mehrere Oberflächen eines Scanner-Gehäuses (10) er-
- folgt; und  
daß der Abtastschritt folgendes umfaßt:  
das Vorsehen eines rotierenden Abtastmechanismus (35) im Scanner-Gehäuse (10);  
das Bilden des Abtastbereichs (20) zwischen einer ersten Oberfläche, die sich in einer vertikalen Ebene befindet, die einer Seite des Abtastbereichs zugewandt ist, und einer zweiten Oberfläche, die sich in einer weiteren Ebene befindet, die einer zweiten Seite des Abtastbereichs zugewandt ist;  
das Abtasten in mehreren Richtungen durch Erzeugen einer ersten Gruppe von Abtaststrahlen und einer zweiten Gruppe von Abtaststrahlen durch Reflexion des Laserlichts am rotierenden Abtastmechanismus, wobei die erste Gruppe von Abtaststrahlen an einer ersten Anordnung an Richtspiegeln und aus der ersten vertikalen Oberfläche reflektiert wird, um ein erstes Abtastmuster an Abtastlinien im Abtastbereich zu erzeugen, und wobei die zweite Gruppe von Abtaststrahlen an einer zweiten Anordnung an Richtspiegeln und aus der zweiten Oberfläche reflektiert wird, um ein zweites Abtastmuster von Abtastlinien im Abtastbereich zu erzeugen.
26. Verfahren nach Anspruch 25, worin die zweite Oberfläche in einer horizontalen Ebene unterhalb des Abtastbereichs (20) positioniert ist.
27. Verfahren nach Anspruch 25, worin die zweite Oberfläche in einer vertikalen Ebene parallel und zugewandt zur ersten Oberfläche auf einer Seite des Abtastbereichs gegenüber der ersten Oberfläche positioniert ist.
- Revendications**
1. Dispositif de balayage à code barres de point de vente pour balayer des étiquettes à code barres sur des objets se déplaçant à travers une région de balayage (20) comprenant :
- un convoyeur d'objets (16) pour recevoir des objets placés sur celui-ci et pour déplacer les objets à travers un trajet d'objets ;
- un balayeur de codes barres (10) pour balayer par un ou plusieurs faisceaux lasers un volume d'espace dans lequel une étiquette à code barres de produit doit être située, pour lire l'étiquette, le balayeur de codes barres (10) ayant une source laser dans un boîtier de balayeur ;
- un moyen de décodage (110) pour recevoir des signaux du balayage d'étiquettes à code barres ;
- caractérisé en ce que :
- le balayeur de codes barres (10) a des moyens de balayage pour balayer en directions

multiples pour lire l'étiquette qui pourrait être située sur n'importe laquelle d'un nombre de surfaces différentes de l'objet, les moyens de balayage comprenant :

la source laser pour produire le ou les faisceaux lasers;

un boîtier de balayeur avec une première surface sensiblement verticale et une surface sensiblement horizontale formant la région de balayage (20) entre elles ;

un mécanisme de balayage unique (35) ayant un certain nombre de miroirs (36) pour réfléchir le ou les faisceaux lasers dans un certain nombre de directions pour produire un certain nombre de faisceaux de balayage (38) ;

un certain nombre de miroirs de déviation (40-41, 43-44, 45-46) sont prévus pour réfléchir des faisceaux de balayage à travers la surface verticale pour produire un premier motif de balayage de lignes de balayage (42, 47, 48) ; et

un certain nombre de miroirs de déflection (65-84) pour réfléchir des faisceaux de balayage à travers la surface horizontale pour produire un second motif de balayage de lignes de balayage (58, 60)

2. Dispositif de balayage selon la revendication 1, comprenant des moyens de lecture de fond et un convoyeur de région de balayage mobile (18) qui comprend un certain nombre de bandes de courroie parallèles (55), avec des moyens pour balayer un faisceau (58, 60) jusqu'à travers des espaces entre les bandes de courroie et jusqu'à travers des espaces transversaux à l'une ou l'autre extrémité du convoyeur de région de balayage pour lire un code barres situé sur le fond de l'objet.

3. Dispositif de balayage selon la revendication 1 ou la revendication 2, dans lequel le moyen pour balayer en directions multiples comprend un moyen pour balayer le faisceau laser avec une profondeur de champ améliorée susceptible de résoudre une étiquette à code barres UPC ou autre code barres.

4. Dispositif de balayage selon l'une quelconque des revendications précédentes, comprenant un moyen de retour d'objets pour retourner des objets "non lus" que le balayeur n'a pas pu lire.

5. Dispositif de balayage selon l'une quelconque des revendications précédentes, dans lequel le convoyeur d'objets comprend un certain nombre de convoyeurs séparés positionnés en série, comprenant une première courroie courte de convoyeur (16), suffisamment courte pour décourager un client de placer plus qu'un objet sur

le premier convoyeur et une courroie de convoyeur de région de balayage (18) en aval de la première courroie de convoyeur pour transporter des objets à travers la région de balayage (20).

6. Dispositif de balayage selon la revendication 5, dans lequel la courroie de convoyeur de région de balayage (18) a une vitesse qui est supérieure à la vitesse de la première courroie de convoyeur (16) de sorte qu'un objet dans la région de balayage (20) se déplace plus rapidement qu'un objet approchant la région de balayage, réduisant de la sorte la possibilité d'un objet atteignant la région de balayage avant qu'un objet précédent ait quitté la région de balayage.

7. Dispositif de balayage selon la revendication 5, comprenant de plus un moyen pour augmenter la vitesse de la courroie de convoyeur de région de balayage (18) une fois qu'un objet a été lu.

8. Dispositif de balayage selon l'une quelconque des revendications précédentes, comprenant de plus un système d'amélioration de profondeur de champ pour les faisceaux de balayage, comprenant :

des première et seconde sources lasers séparées (106, 108), chacune produisant un faisceau laser respectif (100, 102) ;

un moyen de combinaison de faisceaux (104) pour superposer les deux faisceaux lasers sensiblement sur un trajet de faisceau unique, les faisceaux étant orientés dans la même direction ;

un moyen de focalisation associé à chacun des faisceaux lasers, comprenant un premier moyen de focalisation de faisceaux pour focaliser le premier faisceau laser pour converger vers un premier plan focal à une première position dans l'espace et un second moyen de focalisation de faisceaux pour focaliser le second faisceau laser pour converger vers un second plan focal à une seconde position dans l'espace, espacé du premier plan focal;

chaque faisceau laser ayant un rétrécissement du faisceau suffisamment focalisé pour résoudre un code barres typique et les deux plans focaux des deux faisceaux lasers étant espacés d'une distance telle que la plupart du rétrécissement du faisceau du second faisceau laser est non coextensive du rétrécissement du faisceau du premier faisceau laser afin d'ajouter généralement les deux rétrécissements de faisceau pour produire une profondeur de champ résolvant un code barres effectif plus longue que l'étranglement de faisceau de l'un ou l'autre des deux faisceaux lasers.

9. Dispositif de balayage selon la revendication 8, dans lequel les première et seconde sources lasers comprennent des diodes lasers (106, 108).

10. Dispositif de balayage selon l'une quelconque des revendications 1 à 7, dans lequel la source laser comprend une première diode laser (106) et une seconde diode laser (108), la première diode laser produisant un premier faisceau laser (100) et la seconde diode laser produisant un second faisceau laser (102).

11. Dispositif de balayage selon l'une quelconque des revendications 1 à 7, dans lequel la source laser comprend une première source laser (106) produisant un premier faisceau laser (100) et une seconde source laser séparée (108) produisant un second faisceau laser (102).

12. Dispositif de balayage selon l'une quelconque des revendications 8 à 11, dans lequel seulement l'un des faisceaux lasers est émis à chaque fois.

13. Dispositif de balayage selon l'une quelconque des revendications 8 à 12, dans lequel le moyen de décodage (110) mesure, lorsqu'un signal a été reçu, le signal de retour de chaque faisceau alternativement et utilisant le signal à modulation plus large, représentant le faisceau laser dans une meilleure focalisation pour décodage.

14. Dispositif de balayage selon l'une quelconque des revendications 8, 9 et des revendications 12, 13, lorsque dépendantes de la revendication 8, dans lequel le moyen de combinaison de faisceaux comprend un séparateur de faisceaux (104) avec des première et seconde sources lasers produisant des faisceaux polarisés dirigés au séparateur de faisceaux à partir d'orientations sensiblement à angles droits les uns par rapport aux autres, avec des faisceaux lasers émergeant du séparateur de faisceaux suivant un trajet de faisceaux commun.

15. Dispositif de balayage selon l'une quelconque des revendications 8 à 14, dans lequel les étranglements de faisceaux sont sensiblement non coextensifs afin d'être complètement additionnés ensemble en tandem pour produire une profondeur de champ de résolution de code barres essentiellement égale à la profondeur de champ totale des deux étranglements de faisceaux.

16. Dispositif de balayage selon l'une quelconque des revendications 8 à 15, comprenant un moyen de commutation de sources lasers pour commuter les première et seconde sources lasers en service et hors service en opposition l'une avec l'autre à une périodicité fixe.

17. Dispositif de balayage selon l'une quelconque des revendications 8 à 16, comprenant un moyen automatique pour également commuter les première et seconde sources lasers en service alternativement pour déterminer le caractère de réflexion de lumière réfléchie reçue et pour choisir la source laser ayant le meilleur signal de retour indiquant la meilleure focalisation et pour continuer la ligne de balayage avec cette source laser.

18. Dispositif de balayage selon l'une quelconque des revendications précédentes, dans lequel la pluralité de miroirs de déflexion comprend un certain nombre de paires de miroirs (40-41, 45-46, 65-66) où une ligne de balayage respective est produite en dirigeant un faisceau de balayage respectif (38) hors d'un premier miroir de déflexion (40, 43, 45, 65) d'une paire de miroirs et subseq̄uement hors d'un second miroir de déflexion (41, 44, 46, 66).

19. Dispositif de balayage selon l'une quelconque des revendications précédentes, dans lequel le mécanisme de balayage comprend une roue rotative.

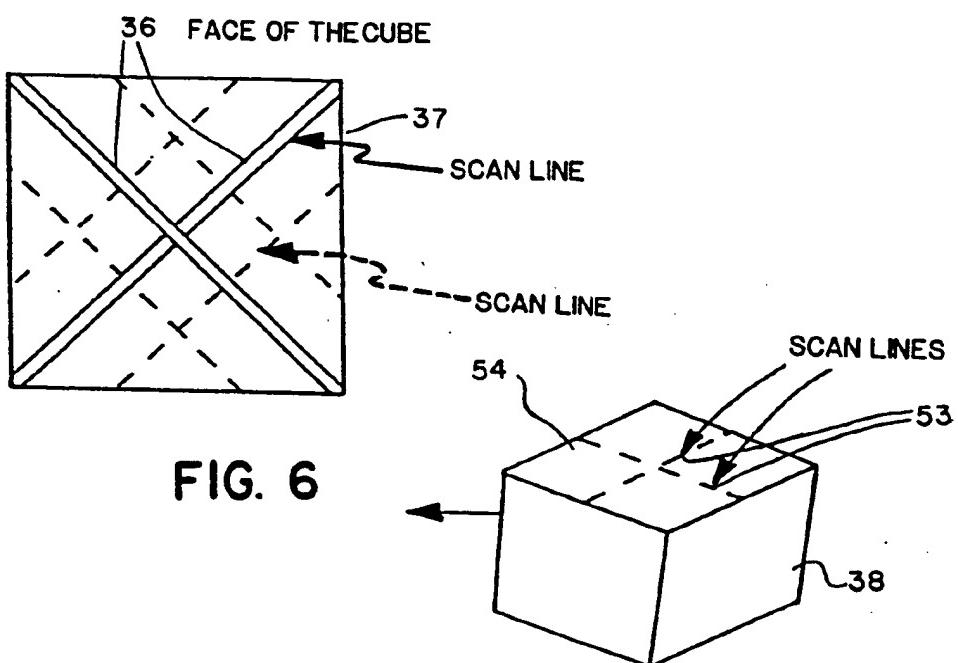
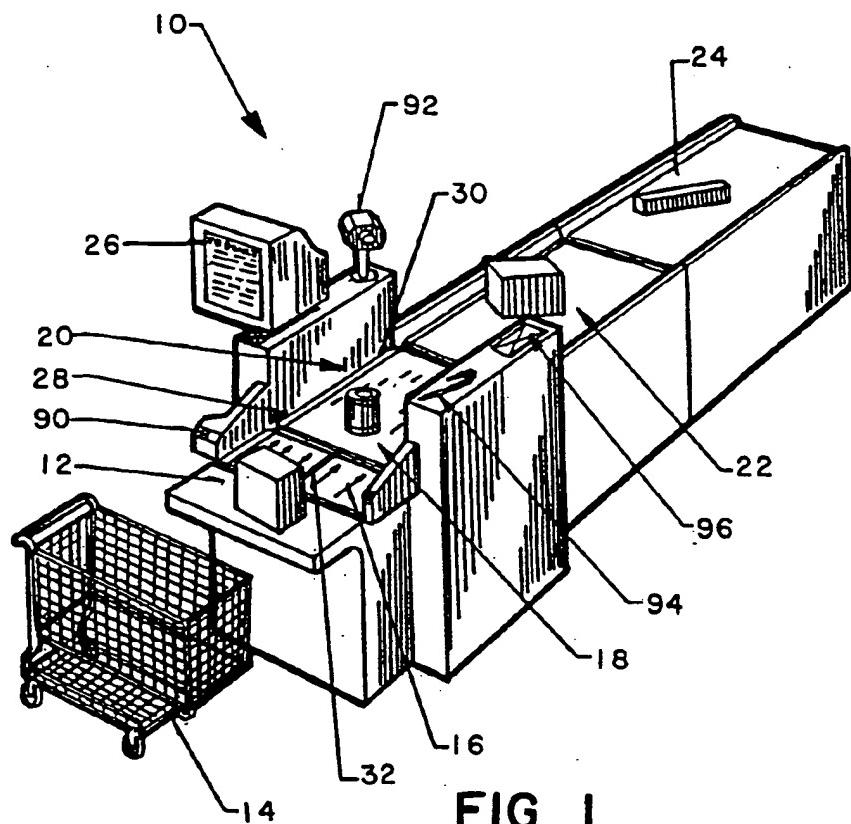
20. Dispositif de balayage selon la revendication 19, dans lequel la roue rotative comprend une roue de distributeur ayant un certain nombre de supports de miroirs montés sur celle-ci, chaque miroir sur le mécanisme de balayage étant monté dans un support de miroir respectif.

21. Dispositif de balayage selon l'une quelconque des revendications précédentes, comprenant de plus une seconde surface verticale positionnée parallèle à et faisant face à la première surface verticale, la surface horizontale étant positionnée entre et en dessous des première et seconde surfaces verticales formant de la sorte la région de balayage (20) entre les première et seconde surfaces verticales et au-dessus de la surface horizontale ; et

un certain nombre de miroirs de déflexion pour réfléchir des faisceaux de balayage à travers la seconde surface verticale pour produire un troisième motif de balayage des lignes de balayage.

22. Dispositif de balayage selon l'une quelconque des revendications 1 à 7, dans lequel la source laser comprend une diode laser unique (106) pour produire une lumière laser consistante en un faisceau laser unique (38), le faisceau laser unique étant dirigé sur le mécanisme de balayage pour produire des faisceaux de balayage.

23. Dispositif de balayage selon l'une quelconque des revendications précédentes, dans lequel le ou les faisceaux lasers sont passés à travers un séparateur de faisceaux (104) entre la source laser et le mécanisme de balayage.
24. Dispositif de balayage selon l'une quelconque des revendications précédentes, dans lequel le mécanisme de balayage comprend deux roues à miroir sur un arbre rotatif, chaque roue à miroir recevant un faisceau laser.
25. Procédé pour automatiquement balayer des étiquettes à code barres sur des objets choisis comprenant les étapes de :
- 16      placer des objets sur un convoyeur d'objets (16) ;
  - 17      déplacer les objets placés sur le convoyeur d'objets (16) à travers un trajet d'objets et à travers une région de balayage (20) ;
  - 18      balayer par un ou plusieurs faisceaux lasers un volume d'espace dans lequel une étiquette à code barres de produit pourrait être située pour lire l'étiquette ;
  - 19      assurer que seulement un objet sera susceptible d'être lu et enregistré à chaque instant ;
  - 20      recevoir et décoder des signaux à partir du balayage des étiquettes à code barres ;
  - 21      compiler des données en rapport aux objets dont les codes barres ont été lus et préparer une tabulation de tels objets ;
  - 22      caractérisé en ce que :
  - 23      le balayage avec le ou les faisceaux lasers est en directions multiples à travers des surfaces multiples d'un boîtier de balayeur (10) ; et
  - 24      l'étape de balayage comprend :
  - 25      prévoir un mécanisme de balayage rotatif (35) dans le boîtier de balayeur (10) ;
  - 26      former la région de balayage (20) entre une première surface positionnée dans un plan vertical qui fait face à un côté de la région de balayage et une seconde surface positionnée dans un autre plan qui fait face à un second côté de la région de balayage ;
  - 27      balayer en directions multiples en produisant un premier groupe de faisceaux de balayage et un second groupe de faisceaux de balayage en réfléchissant la lumière laser hors du mécanisme de balayage rotatif, réfléchissant le premier groupe de faisceaux de balayage hors d'un premier jeu de miroirs de direction et hors de la première surface verticale pour produire un premier motif de balayage de lignes de balayage dans la région de balayage, et réfléchissant le second groupe de faisceaux de balayage hors d'un second jeu de miroirs de direction et hors de la seconde surface pour produire un second motif de balayage de lignes de balayage dans la région de balayage.
- ge.
26. Procédé selon la revendication 25, dans lequel la seconde surface est positionnée dans un plan horizontal en dessous de la région de balayage (20).
27. Procédé selon la revendication 25, dans lequel la seconde surface est positionnée dans un plan vertical parallèle à et faisant face à la première surface sur un côté de la région de balayage opposée à la première surface.



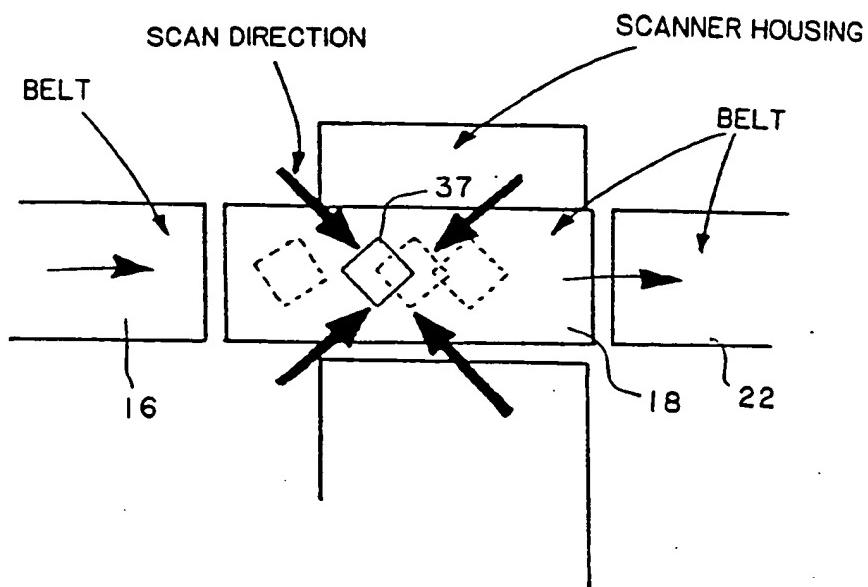


FIG. 4

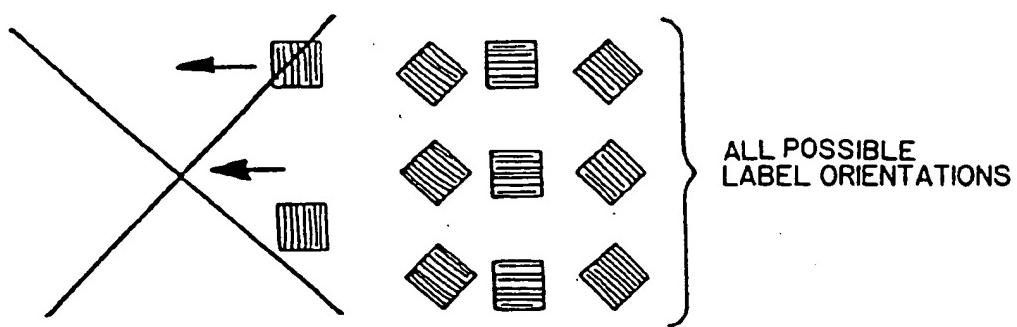


FIG. 5

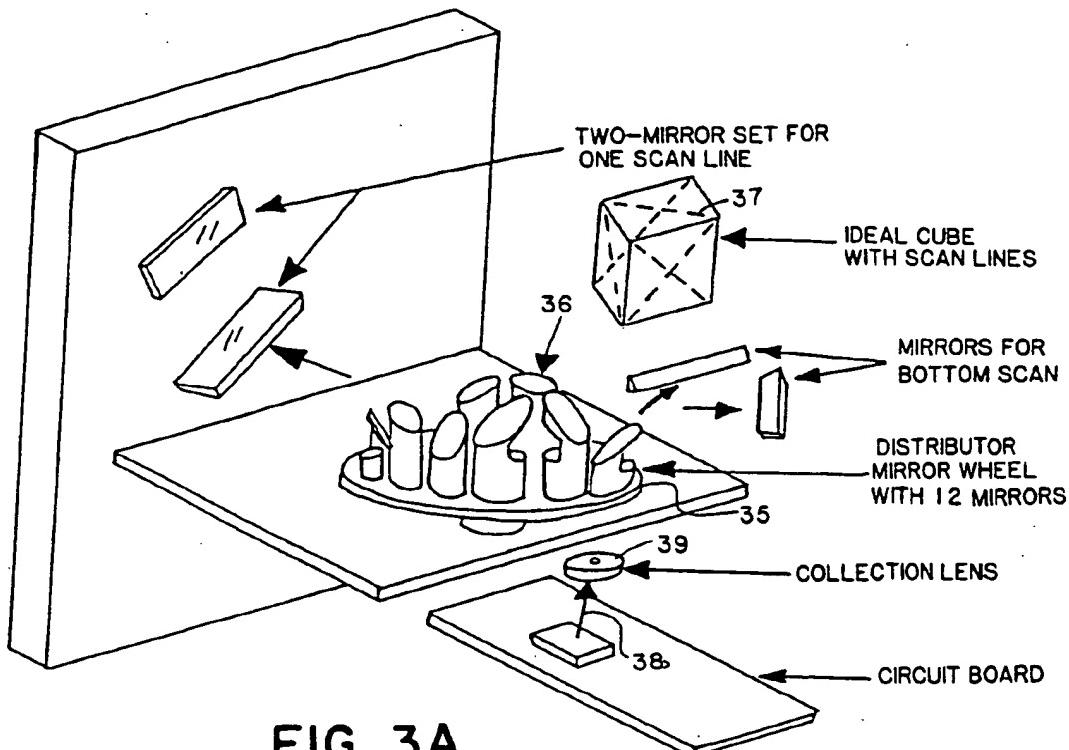


FIG. 3A

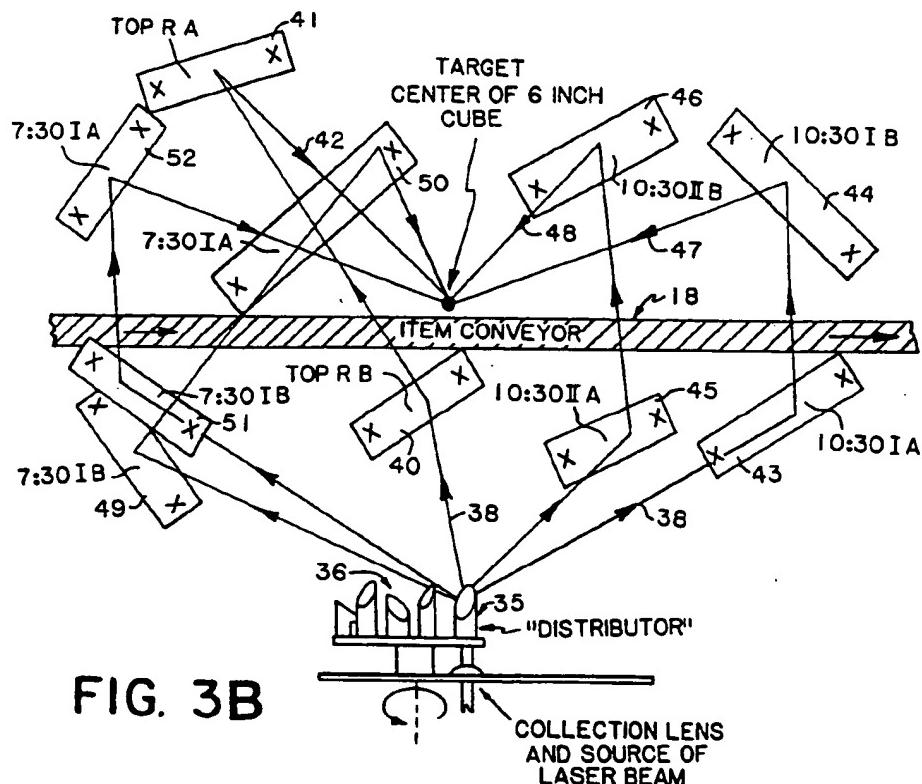


FIG. 3B

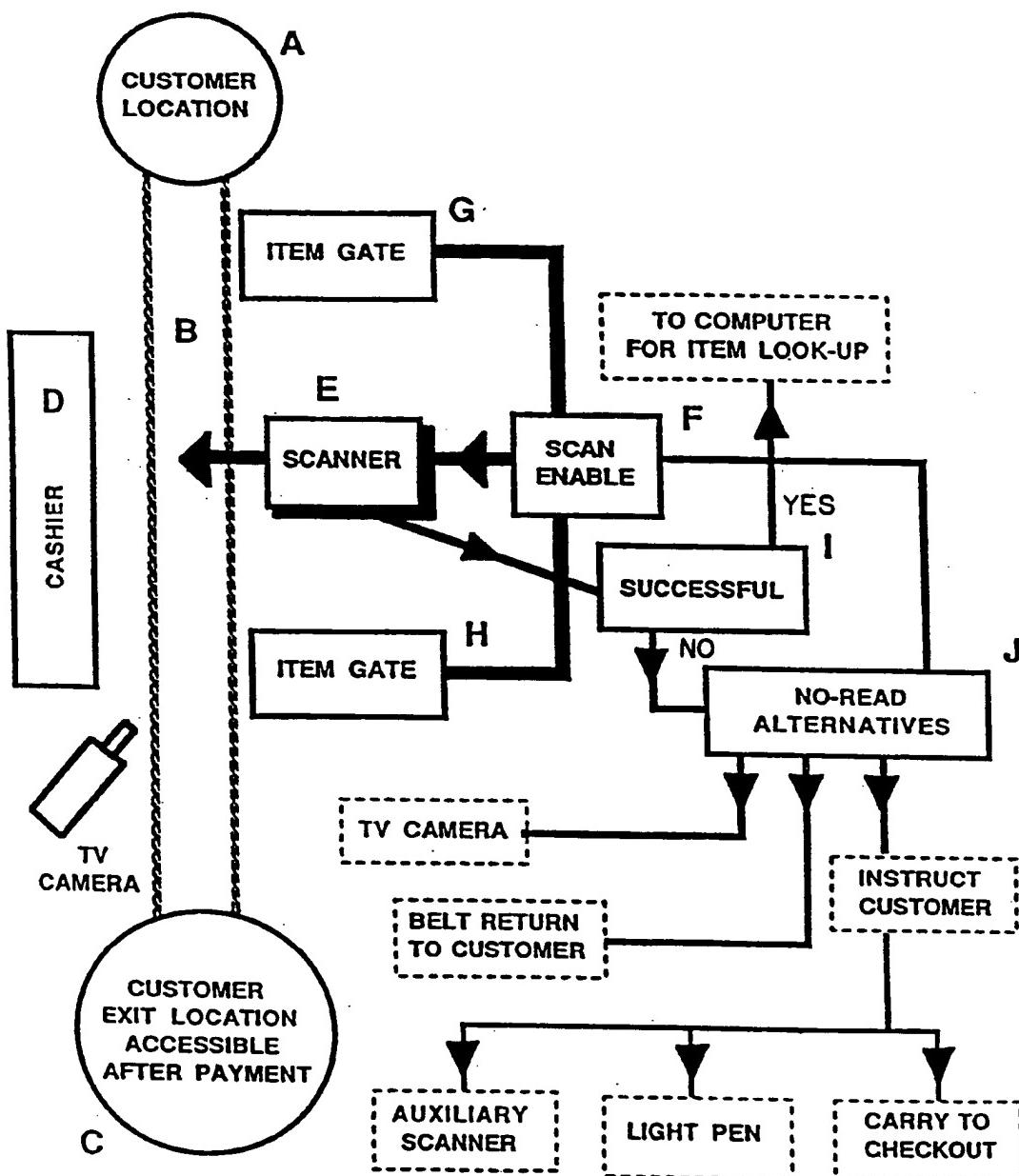


FIG. 2

FIG. 11

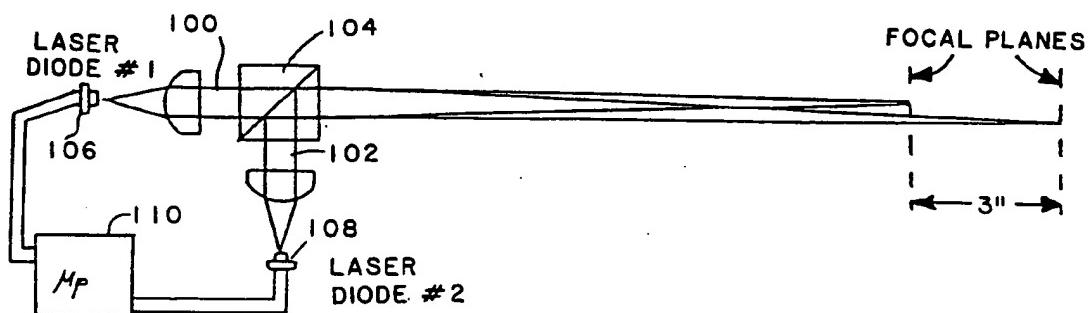
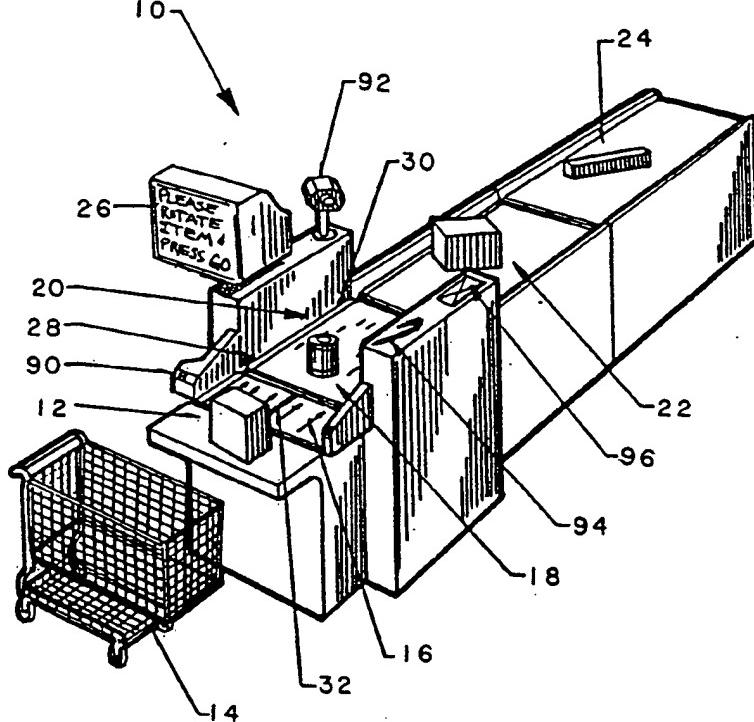


FIG. 12

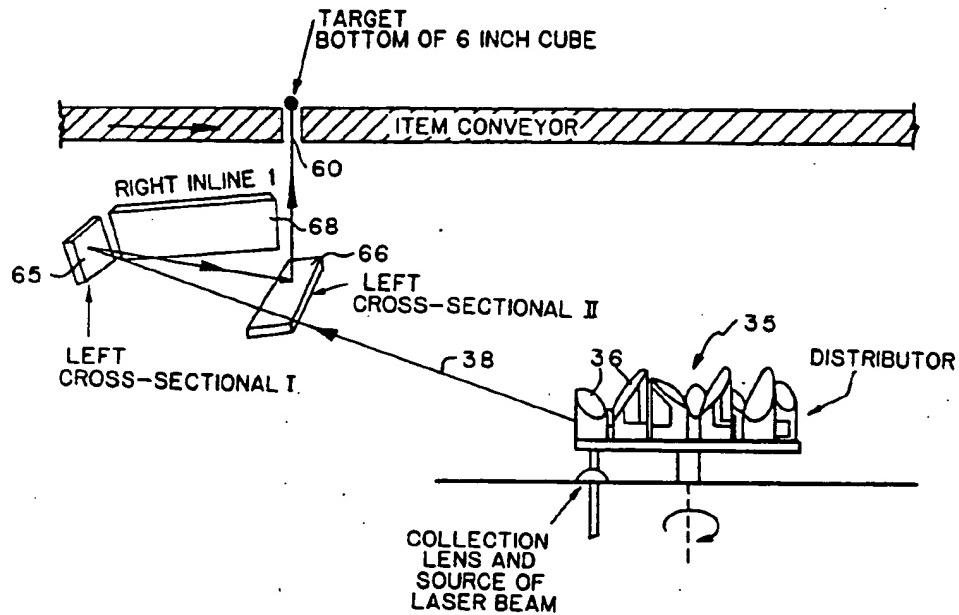


FIG. 10C

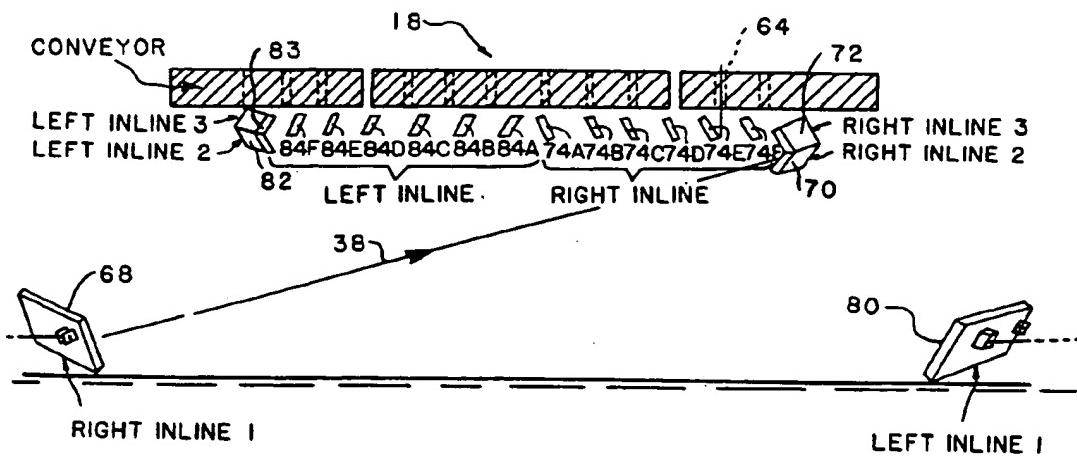


FIG. 10D

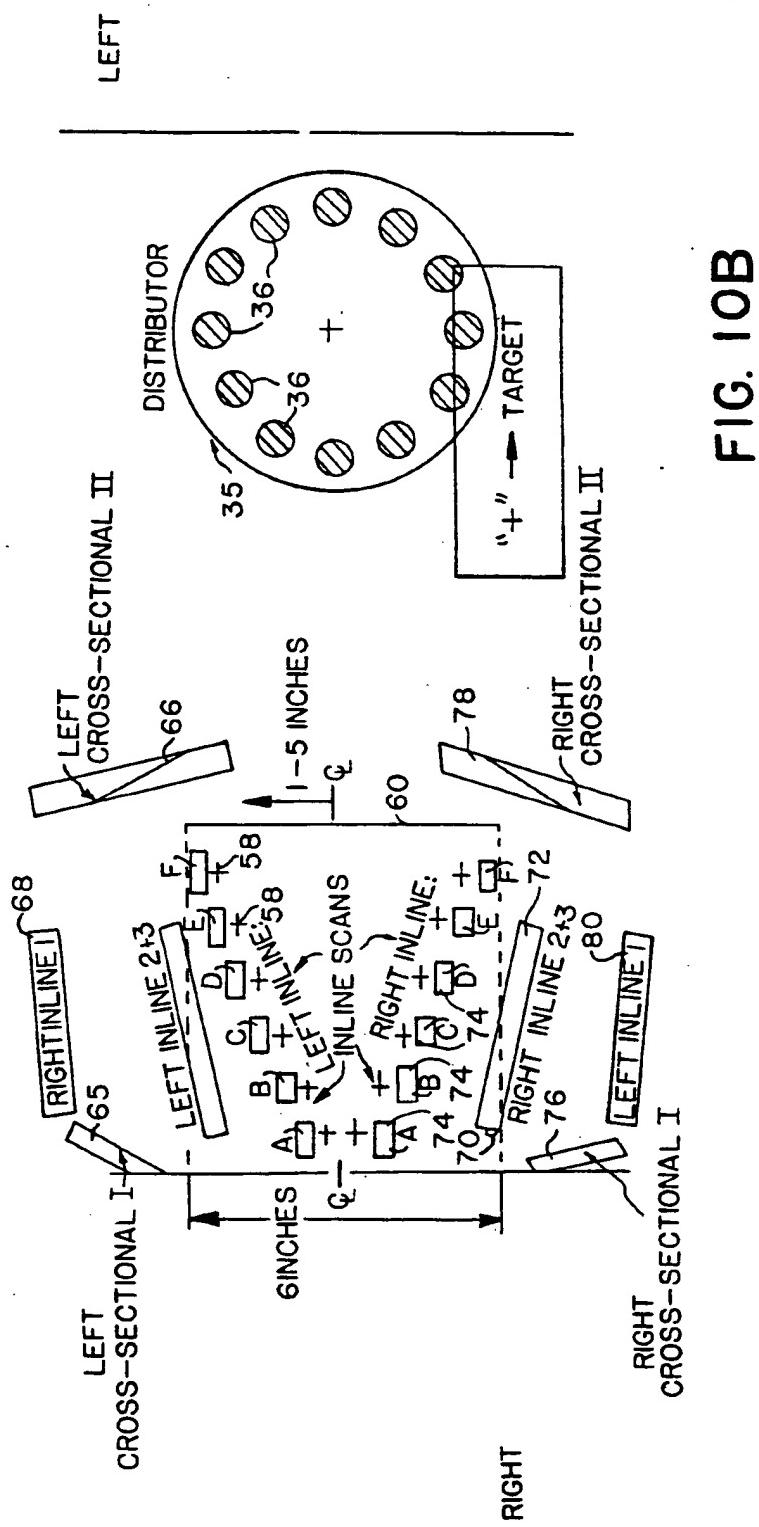
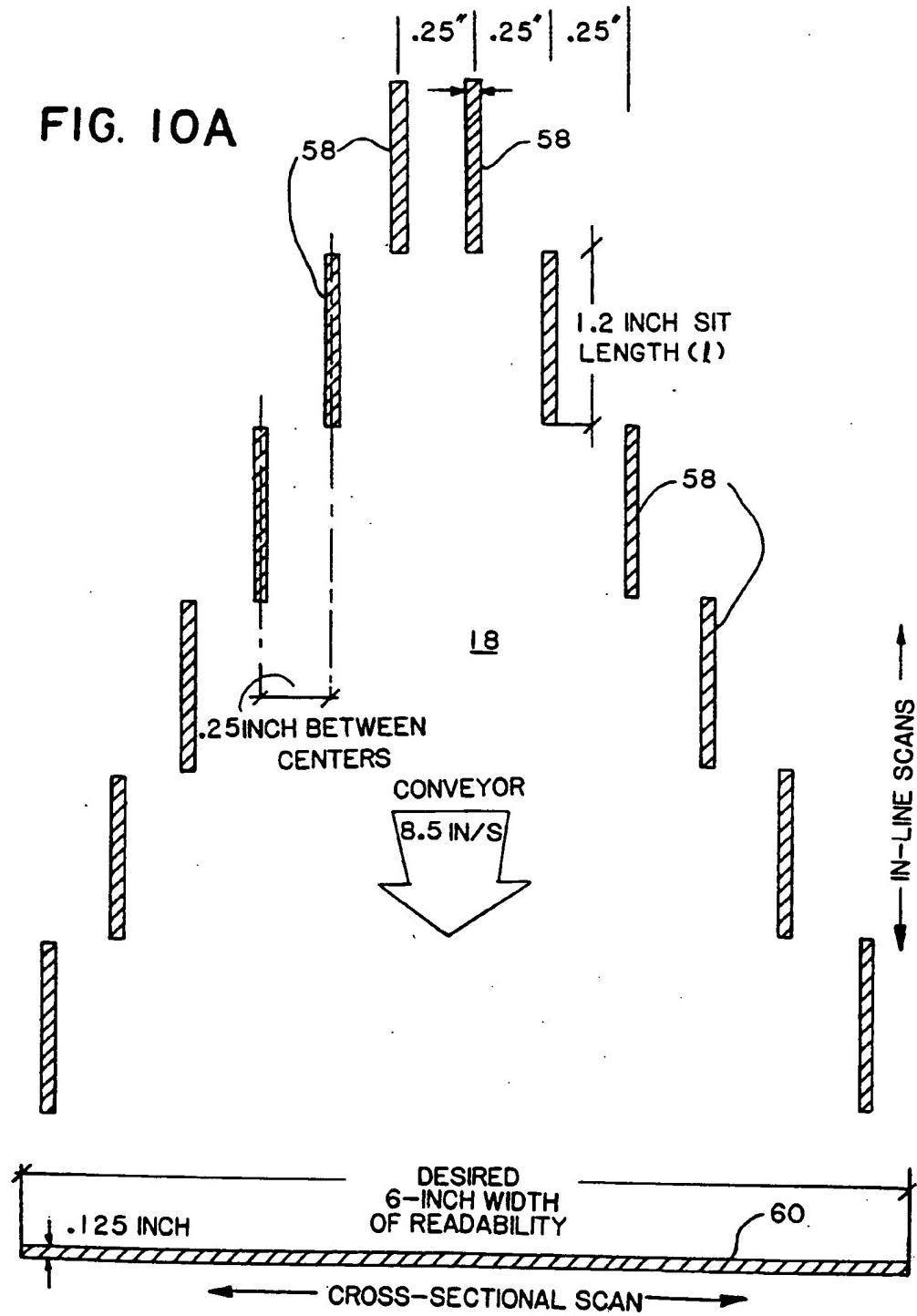


FIG. 10B

FIG. 10A



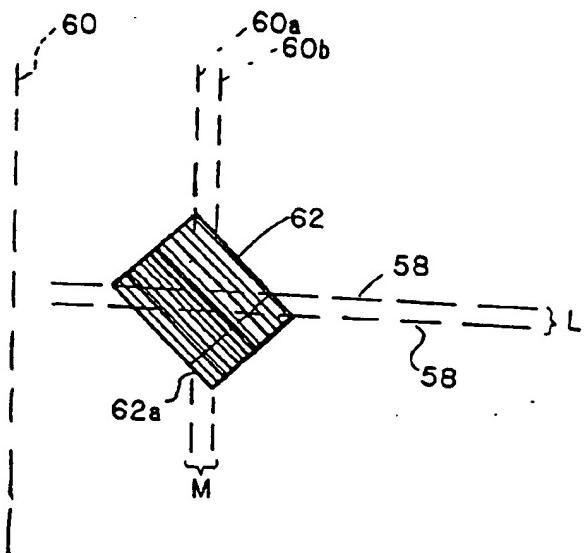


FIG. 9

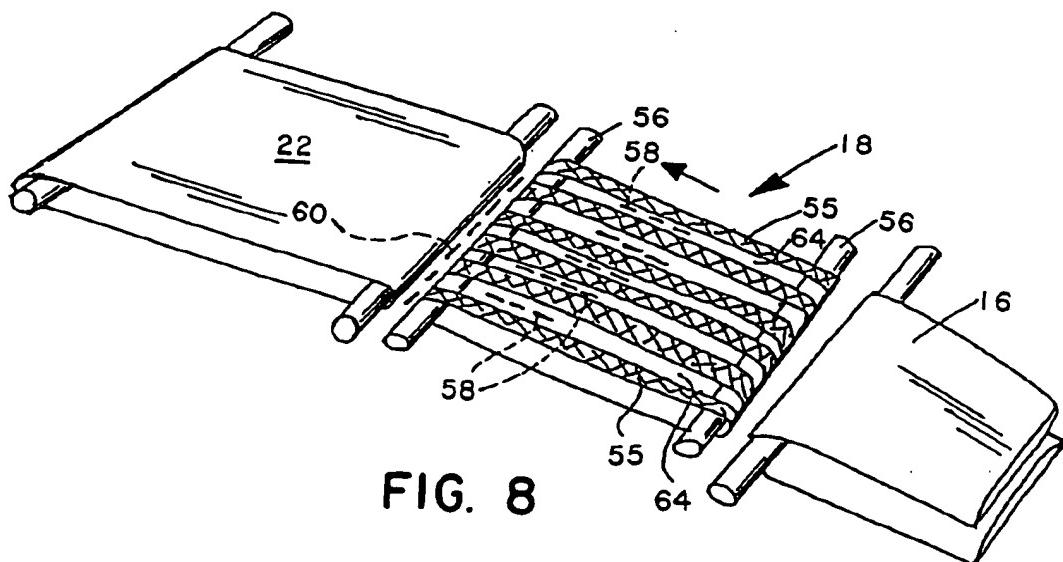


FIG. 8